JOINT PANEL
ON
OCCUPATIONAL AND ENVIRONMENTAL
RESEARCH
FOR URANIUM PRODUCTION
IN
CANADA

1988 ANNUAL REPORT

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The Joint Panel on Occupational & Environmental
Research for Uranium Production in Canada

1989

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FOREWORD

1988 Annual Report of the Joint Panel

I am pleased to submit the 1988 Annual Report of the Joint Panel on Occupational and Environmental Research for Uranium Production in Canada. The annual report is recognized widely as a valuable source of information for members and others interested in this subject, and is widely circulated. It is a report by the members, compiled by the Secretary, and all contributing members should consider it as a means of gaining recognition of their research efforts.

For the first time, a section has been added entitled Joint Panel Publications and the reports from two working groups are now available as output from the Panel. The working groups, of course, put a lot of effort into their assignments, and their efforts should not go unrecognized. On behalf of the Panel, I extend thanks to the members of the working groups for their perseverance.

The Panel also wishes to thank Saskatchewan Human Relations, Labour and Employment as well as AECB for hosting the 1988 sessions of the Panel.

The Panel gratefully acknowledges the contribution made by Dr. J.E. Udd of CANMET's Mining Research Laboratories for providing the services of Dr. R. Tervo as Secretary, and for publishing the Annual Report.

L.D. Brown,
Chairman

JOINT PANEL ON OCCUPATIONAL AND ENVIRONMENTAL RESEARCH FOR URANIUM PRODUCTION IN CANADA

EXECUTIVE - 1988

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Occupational Health and Safety Branch
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Provincial Agencies Representative: Dr. L.D. Brown, Saskatchewan Labour.

Federal Agencies Representative*: Dr. J. Bigu, CANMET, EMR Canada.

Union Representative*: Mr. H. Seguin, USWA.

*See membership list, page 46, for addresses and telephone numbers.

SUPPORTING MEMBER ORGANIZATIONS, 1988

Atomic Energy of Canada Limited (AECL)
Atomic Energy Control Board (AECB)
Canadian Institute for Radiation Safety (CAIRS)
Denison Mines Limited (DEN)
Eldorado Resources Limited (ERL)
Energy, Mines and Resources Canada (EMR)
Environment Canada (DOE)
Health and Welfare Canada (NHW)
Dept. of Indian Affairs and Northern Development (DIAND)
Key Lake Mining Corporation
Ministry of Labour, Ontario (MOL)
Rio Algom Limited (RIO)
Saskatchewan Environment (SE)
Saskatchewan Human Resources, Labour and Employment (HURLE)
Saskatchewan Mining Development Corporation (SMDC)
United Steelworkers of America (USWA)

ASSOCIATE MEMBER ORGANIZATIONS, 1988

Cigar Lake Mining Corporation, Saskatchewan
Department of Consumer Affairs and Environment, Newfoundland and Labrador
Department of Mines and Energy, Newfoundland and Labrador
Department of Mines and Petroleum Resources, British Columbia
Labour Canada
Mines Accident Prevention Association of Ontario
Ministry of the Environment, Ontario
Ministry of Northern Development and Mines, Ontario
Saskatchewan Research Council
Saskatchewan Mining Association
Technical Advisory Committee on the Nuclear Fuel Waste Management Program
Uranerz Exploration and Mining Limited

TERMS OF REFERENCE

1.0 INTRODUCTION

1.1 The name of the panel shall be "The Joint Panel on Occupational and Environmental Research for Uranium Production in Canada".

1.2 Where appropriate, the name of the panel may be shortened to "The Joint Panel".

1.3 The Joint Panel is a Canadian organization whose members have voluntarily agreed to share information regarding research into the effects of uranium production on the health and safety of workers and the protection of the environment.

2.0 OBJECTIVES

2.1 The primary objectives of the Joint Panel shall be:

(a) identification of those areas related to the occupational health and environmental effects of uranium production in which there is a need for research; and

(b) stimulation of research in areas in which a need has been identified.

(c) the production areas of interest are mining and milling.

2.2 To meet its primary objectives the Joint Panel will:

(a) produce and distribute an annual inventory of current and completed research in relevant areas being conducted by Supporting Members (the Annual Report); and

(b) provide a forum for the exchange and dissemination of information on proposed, current and completed research.

3.0 MEMBERSHIP

3.1 Supporting Membership is open to any organization that actively and continually supports research on the occupational or environmental effects of uranium production.

3.2 Associate Membership is open to those organizations who:

(a) have responsibility or authority relating to occupational or environmental effects of uranium production, but do not actively support research activities; or

(b) are interested in the activities of the Joint Panel, but do not qualify as, or do not wish to become, a Supporting Member.

3.3 Admission to membership in the Joint Panel shall be granted by simple majority vote of the Supporting Members present at any meeting of the Joint Panel.

3.4 Any Supporting Member who is not active in the work of the Joint Panel may be reclassified as an Associate Member by simple majority vote of the Supporting Members present at any meeting of the Joint Panel if such action is requested by the Executive.

3.5 Participation on the Joint Panel will in no way constrain members from pursuing their own organizational or institutional objectives.

4.0 SUPPORTING MEMBER ORGANIZATIONS

4.1 A Supporting Member is expected to contribute to the development of a comprehensive program of research compatible with its roles and responsibilities.

4.2 A Supporting Member is expected to recognize its obligation to make information widely available by:

(a) providing information to the membership of the Joint Panel on current research which they are supporting;

(b) reviewing reports prepared by other Supporting Members and providing comments:

(c) participating in the activities of the Joint Panel.

4.3 A Supporting Member is expected to recognize the need to make final research results available to the membership and to the public.

4.4 Each organization that is a Supporting Member shall designate an individual as its Representative on the Joint Panel.

4.5 Each Supporting Member shall advise members of the Joint Panel of the individual or unit within their organization to which requests for publication should be directed. This information will be included in the Annual Report.

5.0 THE EXECUTIVE

5.1 The affairs of the Joint Panel will be administered by the Executive.

5.2 The Executive shall consist of the Secretary of the Joint Panel and four other individuals. Each of these other individuals must be the designated Representative of a Supporting Member.

5.3 The individuals who are members of the Executive will be chosen to represent four groups that have Supporting Members on the Joint Panel, the four groups being:

(a) The Federal Government;

(b) The Provincial Government;

(c) Industry: and

(d) Labour.

5.4 It shall be the responsibility of each group to select one individual who will represent the group on the Executive. A selected individual shall serve on the Executive for four years from the 1st of January following his selection.

5.5 All decisions of the Executive shall be by consensus. The Executive may decide any matter placed before it on behalf of the Joint Panel.

5.6 Where a consensus on any matter cannot be reached by the members of the Executive, the question shall be referred to the Supporting Members at the next meeting of the Joint Panel, at which time the matter will be decided by a simple majority vote of the Supporting Members present.

5.7 The Executive is authorized to make news releases, in the name of the Joint Panel, from time to time regarding the functioning of the Panel, its role, and the nature and extent of research being conducted.

6.0 THE CHAIRMAN

6.1 The Executive shall select from among its number an individual to serve as Chairman. The selected individual shall serve as Chairman for 1 year from the 1st of January following his selection.

6.2 The Chairman will preside at all meetings of the Joint Panel and of the Executive.

6.3 In case of the absence of the Chairman from any meeting, any other member of the Executive may preside.

6.4 The Chairman, in consultation with the other members of the Executive, shall be responsible for arranging the meetings of the Joint Panel.

7.0 THE SECRETARIAT

7.1 Energy, Mines and Resources Canada (EMR) will provide the necessary Secretariat and publish the Annual Report.

7.2 EMR will appoint an individual to be the Secretary of the Joint Panel.

7.3 EMR may designate the individual who is the Secretary as their Representative to the Joint Panel, or may designate some other individual.

8.0 MEETINGS

8.1 The Joint Panel will meet semi-annually. Normally there will be a Spring meeting (generally in June) and a Fall meeting (generally in December).

8.2 Each meeting of the Joint Panel will include time for:

(a) conducting business relating to the functioning of the Panel;

(b) distribution of information relating to research projects; and

(c) technical sessions.

8.3 Notice of each meeting shall be sent, by the Secretariat, to the designated Representative of each Supporting Member and to each Associate Member. Included with the notice of meeting will be an agenda.

8.4 Attendance at meetings is restricted to designated Representatives of each Supporting Member, and alternates, Associate Members and observers invited by a member of the Executive. However, technical sessions are open to any interested person at the discretion of the Executive.

9.0 RESEARCH REPORTS

9.1 In order to have a common format for research reports, a system of three forms will be used. The forms will be designated as:

(a) FORM 1: STATEMENT OF PROJECT

(b) FORM 2: REPORT OF PROJECT PROGRESS

(c) FORM 3: PROJECT COMPLETION REPORT

9.2 FORM 1 will be used to advise the members of the Joint Panel of any relevant research project which is to be undertaken or which has commenced but has not previously been reported.

9.3 FORM 2 will be used to advise the members of the Joint Panel of any progress that has been made or of any changes of the scope of a project.

9.4 FORM 3 will be used to advise of the completion or early termination of a project.

9.5 A matrix indicating the various areas of active research of interest to the Joint Panel will be maintained, and each project will be identified as to its position on the matrix.

9.6 A similar matrix indicating areas of completed research projects will also be maintained.

9.7 Each project will be assigned a reference number by the Secretariat. Project reports will be identified by this number.

9.8 A summary of the distribution of active research projects on the matrix will be maintained by the Secretariat, and a copy of this summary will be distributed at each meeting of the Joint Panel.

10.0 TECHNICAL SESSIONS

10.1 The technical sessions held at meetings of the Joint Panel will consist of presentations of invited papers, discussions of current topics and/or field trips.

10.2 It shall be the responsibility of the Executive to organize the technical sessions.

10.3 In selecting papers or topics for presentation at technical sessions, preference will be given to topics related to completed or ongoing research projects.

JOINT PANEL ACTIVITIES - 1988

Two regular business meetings were held during 1988.

Summer Meeting - June 21-22, 1988.

The summer meeting was held on June 21 at the office of Saskatchewan Human Resources, Labour and Employment (HURLE) in Regina with Denis Brown acting as host. Thirteen organizations were represented, Sask. (HURLE), CANMET, United Steel Workers of America, Technical Advisory Committee to AECL, AECB, Sask. Environment, Sask. Research Council, Sask. Mining Association, Key Lake Mining Corp., Health and Welfare Canada, Midwest Joint Venture (Denison) and Environment Canada.

Projects were reviewed, and reports were received from the working groups.

E. Rabin, AECB, was the speaker for the technical session, with a presentation entitled "Comparison of the Distributions of Non-Radiological to Radiological Fatal Risk in the Ontario Mining Industry".

A tour of Sask. HURLE laboratory facilities was available on June 22nd.

Fall Meeting

The 1988 fall meeting of the Joint Panel was held at the AECB office, Ottawa. Thirteen organizations were represented, AECL, AECB, CANMET, Sask. HURLE, Key Lake Mining Corp., Health and Welfare Canada, United Steel Workers of America, Sask. Mining Association, CAMECO, Cigar Lake Mining, DIAND and Denison Mines Ltd. The technical session was attended by Dr. G. Skippen of Carleton University as a representative of the Technical Advisory Committee to AECL, as well as four additional staff members of AECB.

The technical session consisted of four presentations:

W.G. Jeffery (MITEC)	The Mining Industry Technology Council of Canada.
D. Killey (AECL)	Model Validation Studies of Ground Water Contamination Transport.
R. Maloney (AECB)	Wetlands and Biological Polishing.
M. Campbell (CANMET)	The Mine Environmental Neutral Drainage Program (MEND).

REPORTS BY WORKING GROUPS

1) High Grade Ores - J. Bigu and P. Duport reported on progress at the Fall Meeting.

2) Internal Dosimetry - Report to be published.

3) Personal Dosimetry - J. Bigu and P. Duport, report to be published.

Proposed Working Group - Occupational Hazards.
Members: D. Brown, D. Mellor, E. Rabin.

ACTIVE RESEARCH PROJECTS

ATOMIC ENERGY OF CANADA LTD. (AECL)

Environmental Effects

101. Environmental pathways analysis - Aquatic (Chalk River).

102. Environmental pathways analysis - Terrestrial (Pinawa).

103. Environmental pathways analysis - Effects of water flow on sorption of radionuclides (Pinawa).

104. Experimental pathways analysis - Sorption of nuclides onto geologic material (Pinawa).

105. Effect of groundwater components on UO_2 dissolution (Pinawa).

106. Actinide - rock interaction (Pinawa).

107. Environmental impact and stabilization of naturally radioactive waters (Chalk River).

Assessment of Radiation Hazards

108. Quantification of radiation risks (Chalk River).

Radiation Dosimetry

109. Radiation dosimetry and instrumentation development (Chalk River).

110. Internal dosimetry modelling (Chalk River).

111. Deposition of attached and unattached radon daughters (Chalk River).

Assay Methods

112. Bioassay of actinides (Chalk River).

113. In vivo monitoring (Chalk River).

HIGHLIGHTS, ATOMIC ENERGY OF CANADA - D. Myers

Environmental Research - Chalk River Nuclear Laboratories (CRNL)

A. Biosphere Modelling - The Environmental Research Branch is an active participant in the International Biospheric Model Validation Study (BIOMOVS). BIOMOVS is an International cooperation effort to test models designed for the calculation of environmental transfer and bioaccumulation of radionuclides and other trace substances. The primary objectives of BIOMOVS are threefold, namely: to test the accuracy of the predictions of environmental assessment models for selected contaminants and exposure scenarios; to explain differences in model predictions due to structural deficiencies, invalid assumptions and/or differences in selected input data; and to recommend priorities for future research for improvement of the accuracy of model predictions. In this work we have had to develop

criteria for model validation, and methodologies for comparing model performance against those criteria. We have had to delve deeply into the models used by participants so as to explain the causes of differences between predictions and observations. In the course of this work, many errors in the observational data set have been detected and in most cases corrected. An important spinoff from BIOMOVS will have been the assembly of a quality controlled database for the use of future researchers.

B. Transport of Trace Contaminants Between Surface Waters and Sediments - Significant advances in the development and testing of predictive models for contaminant transport in surface waters have been achieved in recent studies at CRNL. The differences in distribution of stable iron concentrations in lake water, in the suspended and sinking particles, and in sediments can be explained by a kinetic model that distinguishes suspended particles with long residence times in the water column from sinking particles with comparatively short residence times. This model predicted the observed partitioning of Fe between water and sediments to within a factor of 3. The success of the two particle compartment model in predicting the partitioning of stable Fe is encouraging for prospects of long range prediction of nuclide behaviour in surface waters.

C. Groundwater Transport of Contaminants - A significant contribution to the understanding of physical processes controlling the movement and spreading of contaminants in groundwater has resulted from the application of radioactive tracers in three natural-gradient dispersion tests performed at the Twin Lake aquifer at CRNL. The combined use of a novel dry-access-tube monitoring technique and a high-energy, gamma-emitting groundwater tracer (iodine-131) resulted in an unprecedented resolution of the tracer distribution; approximately 3/4 of a million data points were calculated during the experiment. This created an opportunity for quantifying the dispersion process at various scales of interest. The tracer site offers a setting where the subsurface transport of contaminants of particular concern can be studied under controlled field conditions. Results at Twin Lake would provide a benchmark against which one could test various laboratory procedures for measuring properties and processes of concern.

The long residence times associated with the migration of highly reactive radioactive materials detrimental to the quality of groundwater preclude the performance of large-scale field tests that are required to validate predictive contaminant models. At CRNL, field observations collected from the existing contaminated sites have been used to assess the validity of existing models in a cooperative research program between the Pacific Northwest Laboratories (PNL) and CRNL. A report has been prepared which describes the results of a comparison of predictive radionuclide transport modelling versus field measurements and plume mapping for the "A" Disposal Area. The limited-data predictive transport modelling provided a reasonable match with the observed down-gradient strontium-90 migration rate. Migration showed 1.8 times more lateral spreading than the predicted migration.

D. Groundwater Discharge to Surface Water - In recent years six techniques were applied to the problems of locating and quantifying sources of groundwater inflow to surface waters. These techniques were used to acquire site-specific information where actual or potential groundwater contamination affected surface-water quality. The methodology incorporates seepage meters, mini-piezometers, a sediment probe, a piston corer and an

in situ column for studies on groundwater transport and mobility of substances in seepage zones. A traditional method, stream gauging, was also used to estimate groundwater inflow in small streams. In some settings, these techniques make it possible: 1) to account for water and contaminants entering surface waters, and therefore, 2) to determine the significance of these contaminant fluxes. Once discharge zones are known, they can be a source of information on the hydrogeological systems feeding them. Application of these techniques in several field studies has illustrated their utility.

E. Development of Laboratory and Field Techniques - A new method for determination of Ra-226 in natural waters has been developed. This method has a number of advantages over traditional methods. No special equipment is required and the counting can be done with commonly available liquid scintillation counters. The method can also handle high concentration of calcium which interferes with most methods of determining Ra-226.

A simple method of estimating low rates of groundwater inflow and outflow through the bottom sediments of surface waters has been developed. The technique uses a one-dimensional advection-diffusion model fitted to measure porewater profiles of two non-reactive solutes, tritiated water and chloride, with the advection rate being calculated by a nonlinear least squares technique. Preliminary measurements suggest that the deuterium concentration of groundwaters and surface waters is sufficiently different that the deuterium profile in sediments can be used to determine the rate of groundwater advection in a manner similar to that used for the other non-reactive tracers.

Prediction of the transport of radionuclides from waste disposal facilities requires an adequate understanding of the processes affecting the transport of specific radionuclides. An alternative approach to long-term field tests or short-term laboratory tests for assessing these processes is the *in situ* field column technique recently developed at CRNL. Columns constructed from undisturbed cores of aquifer matrix are placed in a well that had a screen located at the depth from which the column sediments were previously collected. The columns provide a defined flow system, tracer can be injected from the surface, the porous media with which the tracer was in contact is fully recoverable for analysis, the hydrogeochemical conditions of the aquifer can be closely approximated in the column, and the time needed for the experiment can be selected by controlling the column dimensions.

F. Assessment of Hazards - International interest has been centred on possible revisions of the estimates of risk of fatal cancer per unit radiation dose, and on methods for measuring and adding up the various sources of radiation to which uranium miners are exposed. At present, it appears that the risk estimates for occupational exposures will probably be increased by a small factor. Considerations of dosimetry and internal metabolism of long-lived radionuclides in inhaled ore dust suggest, on the other hand, that present recommendations on annual limit of intake are too low in the particular case of underground uranium mines.

ATOMIC ENERGY CONTROL BOARD (AECB)

202. Ontario miners mortality study (Phase II).

209. Study of the health effects of inhaled radioactive dust.

210. The Canadian National Dose Registry study (Health and Welfare Canada, Statistics Canada).

219. Measurement of the thickness of bronchial epithelium.

222. Comparison of the techniques used in estimating past exposures to radon daughters in Canadian mines.

232. Determination of radon and thoron fluxes in uranium mines (Ontario). (Denison Mines Ltd.).

233. Determination of radon flux in uranium mines (Saskatchewan).

234. Calibration of wire screen collectors in the measurement of the unattached fractions of radon and thoron progeny in air.

235. Modified personal alpha-dosimeter for Canadian uranium miners.

238. Transfer parameter: non-domesticated animals.

241. Technical evaluation of an instant working level meter.

243. Ontario miners mortality study - Phase III. (OML, WCBO).

244. Remeasurement of Th-230 in the pore water of Lacnor tailings.

245. Radiation sensitivity of organisms other than man: a review.

246. Effect of soil on radionuclides in plants: a field study.

247. Calibration validation of FEMWATER/FEMWASTE on the Nordic site.

248. Study of the effect of uranium on kidney function.

249. Erosion of surface and near-surface disposal facilities.

250. Methodology for estimating probability of intrusion.

251. Optimization in the decommissioning of uranium tailings.

252. Physical characteristics and solubility of long-lived airborne particulates in uranium producing and manufacturing facilities.

253. Evaluation of data and models on uranium metabolism.

254. Influence of macrophages on dissolution of uranium compounds.

255. Influence of trace gases on the mobility of radon daughters.

256. Tracer gas method for assessing ventilation efficiency.

257. Review of thorium intake, organ burden and excretion rates.

258. Epidemiological study of lung cancer among uranium miners of ERL at Beaverlodge, Saskatchewan.

259. Evaluation of exposure records of Eldorado miners.

HIGHLIGHTS, ATOMIC ENERGY CONTROL BOARD - H. Stocker

Since the publication of the 1987 Annual Report, AECB has reported on the completion of sixteen research projects and the publication of five reports.

At the June 1988 meeting of the Joint Panel, AECB reported that eleven research projects had been completed and three reports were published.

One of these reports pertains to the transfer of radionuclides through ecological systems: "Transfer of Radionuclides to Human Milk - Phase 2 Feasibility Study", (INFO 0192-2).

The second report presents information on uranium intake and the resulting organ burdens and excretion: "Catalogue of Data on Uranium Intake, Organ Burden and Excretion", (INFO 0260).

The third report investigates the use of supplementary information from social insurance number (SIN) data files in the analysis of occupational mortality among miners: "Improved Mortality Searches for Ontario Miners Using Social Insurance Index Identifiers", (INFO-0264).

A fourth report, produced in-house, has been published that compares positive and negative implications of using personal alpha-dosimetry instead of conventional area monitoring: "Comparing Personal Alpha Dosimetry with Conventional Area Monitoring - Time Weighting Methods of Exposure Estimation: A Canadian Assessment", (INFO 0257).

The following is a brief presentation of the salient points of these projects.

The report "Transfer of Radionuclides to Human Milk - Phase 2, Feasibility Study" (matrix #240) presents detailed procedures for:

- collecting, storing and shipping human milk samples;
- complete decomposition of human milk samples by nitric acid-perchloric acid oxidation;
- sequential separation and determinations of lead-210, radium-226, thorium-230, natural thorium and natural uranium from decomposed human milk solutions.
- the report also outlines a proposed field study program.

The report "Catalogue of Data on Uranium Intake, Organ Burden and Excretion" (matrix #242) describes the collection methods used and presents catalogues of the data on human and animal studies that have resulted from exposures under controlled experimental conditions, chronic occupational or environmental situations, and acute accident conditions.

The report "Improved Mortality Searches for Ontario Miners Using Social

Insurance Index Identifiers" (matrix #208) shows that the use of the SIN identifiers considerably increases the accuracy of death searches. The results of this project are applicable to future studies of mortality experience of occupational cohorts; and in addition makes it possible to investigate quantitatively the effect on accuracy of the death searches when various components of the full names, birth dates, etc., are deleted from the search records.

The report "Comparing Personal Alpha Dosimetry with the Conventional Area Monitoring - Time Weighting Methods of Exposure Estimation: A Canadian Assessment" assesses the performance of the dosimeters and compares the dosimetry techniques used by uranium mining companies in Canada.

At the November meeting of the Joint Panel, AECB reported that five more research projects had been completed, and two reports published. Both of these reports pertain to the ecological impact of tailings disposal:

1. The Waste Management Implications of Concentrating Slimes-II, (INFO-0195-2) and

2. Estimation of Long-Term Probabilities for Inadvertent Intrusion into Radioactive Waste Management Areas: A Review of Methods, (INFO-0275).

One additional report, produced in-house and of potential interest to the Joint Panel, has been published: "Optimization of Protection as a Decision-Making Tool for Radioactive Waste Disposal" (INFO-0267).

The following is a brief presentation of the salient points of these projects.

The report "The Waste Management Implications of Concentrating Slimes-II" (matrix #229) is the second phase of research on the physical and chemical characteristics of fine-grained tailings. This report presents a summary of disposal and management practices for slimes and outlines potential concerns, and, in addition, recommends an approach to disposal planning.

The report "Estimation of Long-Term Probabilities for Inadvertent Intrusion into Radioactive Waste Management Areas: A Review of Methods" (matrix #250) reviews the literature and evaluates methods used to predict the probabilities for unintentional intrusion into radioactive waste management areas in Canada over a 10,000 year period.

The report "Optimization of Protection as a Decision-Making Tool for Radioactive Waste Disposal" was produced in-house and discusses whether optimization of radiation protection is a workable or helpful concept or tool, with respect to decisions in the field of long-term radioactive waste management.

Thirteen additional research projects have been added to the AECB project list for 1988, 247-259 inclusive (see pages 13 and 14). Projects 250 and 251 have been completed, but are shown because they were initiated in 1988.

CANADIAN INSTITUTE FOR RADIATION SAFETY (CAIRS)

HIGHLIGHTS OF CAIRS ACTIVITIES

302. Lung Cancer Detection - Enrolment in the CAIRS Early Lung Cancer Detection Program had increased to 3,200 uranium workers in Elliot Lake by March 31, 1989. The program is sponsored by Rio Algom Ltd. and Denison Mines Ltd. It is free to the workers, voluntary and confidential. Recruitment by CAIRS at the two mining companies continues with strong support of both companies and the union locals. Medical direction is provided by Dr. F.G. Pearson, Professor of Surgery, Faculty of Medicine at the University of Toronto. Cytological analysis is under the direction of Dr. D.W. Thompson, Professor of Pathology, University of Toronto.

303. Personal Alpha-Dosimeters - Work is nearly completed on the development of a plastic injection moulded dosimeter head under an agreement between CAIRS and the French Atomic Energy Commission (CEA). The contract for the work was let to the Saskatchewan Research Council. The project is funded in part by a grant from the National Research Council.

304. Radon in Homes - The CAIRS home radon monitor has been used to test hundreds of homes across Canada since its introduction last fall. The monitor was adapted to home use by CAIRS from the CEA personal alpha-dosimeter.

305. Public Information - The 2nd edition of the CAIRS Radon Information Package was published in February and is being marketed to libraries across Canada. CAIRS has also produced the first in a series of Radiation Facts Sheets. Written by Dr. Ernest Becker, "Radon in Homes" is helping to address the growing number of public enquiries on radon received at the CAIRS Information Centre in Toronto. CAIRS has also given numerous media interviews on radon and other radiation safety concerns.

CAMECO (Previously Eldorado Resources Ltd.)

HIGHLIGHTS, CAMECO - S. Frost

Generally speaking, CAMECO studies are of internal interest, for example, at Beaverlodge.

A study is underway to investigate the use of algae to comb radium from Rabbit Lake effluents.

CIGAR LAKE MINING

HIGHLIGHTS, CIGAR LAKE MINING - C. Burton

During 1988, an exploratory shaft had been developed down 135 ft of a planned 500 ft. A final mining method is yet to be determined.

Data gathering throughout the winter will aid John Kramer, (Whiteshell Nuclear Research Laboratory) with his analog study of the deposit demonstrating long-term geological disposal, applicable to models of spent fuel storage.

DENISON MINES LIMITED (DEN)

232. Determination of radon and thoron fluxes in uranium mines (Ontario) and to validate the VENTRAD model (CANMET).

302. Sputum cytology, Ontario uranium mines (see CAIRS, RIO, USW).

418. Thickened tailings experiment for close-out of uranium mill tailings at Denison Mines Ltd., (CANMET).

As noted in the EMR projects, collaborative studies on both surface and underground environmental problems are being conducted on a regular basis.

ENERGY, MINES AND RESOURCES CANADA (EMR)

CONTINUING ACTIVITIES

500. Instrumentation development (to improve and standardize radiation measurement techniques), (DEN,RIO).

501. Environmental radon (thoron) daughter and radioactive dust level determination, (DEN,RIO).

502. Control strategy development (to identify radon and thoron sources and evaluate control techniques at Canadian uranium mines using continuous monitoring techniques, (DEN,RIO).

503. Development of techniques for assessment of air, water and soil contamination by uranium mine tailings areas (includes characterization of tailings and soil profiles), (RIO,DEN,Laurentian University).

SPECIFIC PROJECTS - UNDERGROUND ENVIRONMENT

504. Tracer gas/radiation recirculation studies - U mines (AECB).

505. Assessment of airflow measuring instruments (AECB).

506. Radon/thoron test facility (erect and operate).

507. Radiation surveys - fluorspar mine (Newfoundland).

SPECIFIC PROJECTS - SURFACE ENVIRONMENT

508. Develop wet barriers on pyritic U_3O_8 tailings (RIO).

509. Consolidation of thickened tailings (DEN).

510. Consolidation of in situ tailings (DEN).

511. Contaminant migration from sulphide uranium tailings (RIO).

UNDERGROUND ENVIRONMENT HIGHLIGHTS - J. Bigu

The objectives are: to develop radiation instrumentation and to undertake studies to determine radiation levels produced in various mining

operations; to identify the major factors affecting the release of radioactive products in mine air; and to develop control methods capable of reducing radiation to acceptable levels.

Instrument Development and Technical Evaluation

A comparison of the performance of the CEA dosimeter sampling head and a modified version of this head designed by CAIRS was conducted in a Radon/Thoron Test Facility. The sampling heads were evaluated in radon/radon progeny only atmospheres and thoron/thoron progeny only atmospheres. The results of this investigation have been published in a recent MRL report.

Several apparatuses have been designed and built to measure the size and electrical charge distribution of:

1. radon progeny and thoron progeny;
2. non-radioactive submicron size aerosols; and
3. long-lived radioactive dust.

These devices include parallel plate elutriators and split flow elutriators with electrical charge deposition capabilities, and diffusion batteries of different geometrical configurations. The above apparatuses have been tested and evaluated in the laboratory using the Radon/Thoron Test Facility (RTTF), and in an underground uranium mine.

No calibration or testing of new instrumentation (monitors, etc.) for radon, thoron, and their progenies have been conducted since the last meeting because no new instruments were available.

National Radon/Thoron Test Facility (RTTF)

Extensive modifications in the airflow system and the air conditioning system have been introduced. Eleven new sampling ports, and other improvements have been added since the last meeting. Although the RTTF still requires extensive modifications to meet the original specifications, it will start operating shortly on an experimental basis, and some preliminary testing and calibration work will be conducted. Work will be initiated by exposing, for instance, charcoal canisters, an operation that requires far less a degree of complexity than testing and calibration of radon daughters and thoron daughters instrumentation. This reduced operation scheme will also give an idea of the practical problems to be encountered in the near future in the testing of a large number of radiation instruments.

Environmental Radiation Level Determination

A major project initiated in order to analyze data (radon, thoron, and their decay products) gathered by Denison Mines Ltd. during 1986/87 has been completed. This study (232) was aimed at:

1. Validating a radiation mine model; and
2. Determining radon and thoron gas fluxes in Denison's underground uranium mines.

These programs have been sponsored by AECB and Denison Mines Ltd. Most experimental work was carried out by Denison Mines personnel. Some experimental work was conducted by the Elliot Lake Laboratory personnel. The

latter analyzed the data collected during the underground monitoring program.

The first and second phases of a project initiated by the Elliot Lake Laboratory and the Department of Labour of the Government of Newfoundland and Labrador have been completed. The project consisted of a field assessment of underground radiation conditions and will be followed by recommendations to implement a suitable radiation monitoring program.

Characterization of Radon (Thoron) and Long-Lived Radioactive Dust

Studies on electrical charge and particle size distribution of Long Lived Radioactive Dust (LLRD) and thoron progeny have been conducted in an underground uranium mine. Electrical charge and particle size distribution determination of radon progeny have been carried out in the laboratory (RTTF).

Electrical charge and size distribution studies on uranium mine and tailings dust will continue in the laboratory, particularly with dusts of high ^{226}Ra content.

The instrumentation used for the above studies was designed and built at the Elliot Lake Laboratories and consisted of parallel plate and split flow elutriators and diffusion batteries. Cascade impactors and other ancillary instrumentation were also used in these studies.

A program to determine α-particle activity (LLRD) in silica dust samples from local underground uranium mines has been re-activated (RIO). Studies on LLRD and Radioactive Dust will be extended as part of a long-term research program aimed at investigating its radiological impact on uranium industry workers.

A research contract entitled "Assessment of Errors in Airflow Measuring Instruments (U-Mines)" has been awarded to the Elliot Lake Laboratory (CANMET) by the AECB.

A major program sponsored by AECB (under contract with the Elliot Lake Laboratory) on the use of tracer gas techniques to evaluate airflow conditions in underground uranium mines is in progress. The program will consist of concurrent measurements of airflow characteristics by radioactivity and tracer gas techniques.

OTHER PROJECTS

In addition to the above, a number of other projects have been undertaken by the Elliot Lake Laboratory, as shown below:

1. A preliminary study on the diffusion characteristics of thoron progeny using batteries of metal wire screens of different sizes has been completed. This work has been conducted in collaboration with the U.S. Bureau of Mines (Denver Research Center, Denver, CO).

2. A study on the electrical characteristics (i.e., electrical charge distribution) of radioactive aerosols (radon progeny) and Long-Lived Radioactive Dust (LLRD) has been initiated. This work was conducted under 'natural' environmental conditions, and by artificially charging the radon progeny by means of a negative ion generator. This study will be extended to thoron progeny in the near future.

3. A preliminary investigation on the transfer of radon and thoron progeny to surfaces by recoil, and possibly other mechanisms, has been completed.

SURFACE ENVIRONMENT HIGHLIGHTS - N.K. Dave and T.P. Lim

Development of Wet Barriers on Pyritic Uranium Tailings (RIO)

The project objective is to establish a saturated hydrologic condition at the surface of pyritic uranium tailings and develop an appropriate wetland vegetative cover to: a) act as an oxygen barrier, and hence control acid generation; b) stabilize the surface; and c) minimize surface water contamination.

Laboratory lysimeter and small scale field 'plot' tests will be carried out on various tailings sites to monitor the effects of the individual or combined effects of treating the tailings by: flooding, leaving them unflooded; treating them with applications of limestone or some other surface ameliorating chemical/substance, revegetation; and leaving them fallow to revegetate naturally.

Procedures and methodologies will be developed to carry out a large scale demonstration on a 40 ha section of the Quirke Mine tailings (west end).

Over a 3-year period, both field and laboratory investigations will be undertaken in order to evaluate the hydrogeochemistry of pyritic uranium tailings with various types of wet barriers.

Hydrogeochemistry of Thickened Tailings (DEN)

An experimental 10,000 tonne thickened tailings pile was constructed in 1982, and its physical and chemical characteristics were measured in detail. Since then the pile has weathered over the last six years. Its characteristic parameters such as physical and chemical stability, saturated and unsaturated zones, hydrogeochemistry, and pore gas oxygen profiles are being reinvestigated to evaluate the use of such a technology as an alternate disposal option for tailings.

In Situ Consolidation of Tailings (DEN)

In situ consolidation permeability and leaching characteristics of various tailings with lime mixtures and cured under nitrogen and carbon dioxide environments are being evaluated. The objective is to evaluate the feasibility of in situ consolidation of an existing tailings pile using lime and carbon dioxide injections.

Contaminants Migration from Sulphide and Uranium Tailings (RIO, DEN, AECB, Laurentian University)

Techniques are being developed to assess migration of contaminants from uranium tailings via air and water pathways. Migration of contaminants from tailings to vegetation, to herbivores and insects, and various other food chains are also being studied to evaluate their ultimate impact on man.

ENVIRONMENT CANADA (DOE)

605. Interaction of radionuclides from abandoned uranium tailings with organic residues.

607. Radionuclides in Langley Bay, Lake Athabaska, Saskatchewan (includes 609).

608. Effects of uranium effluents on an aquatic ecosystem in North Saskatchewan.

615. Radioactivity and fish.

Project 606, Radionuclide distributions in the vegetation of North Saskatchewan and adjacent Northwest Territories, has been completed. This project was sponsored by Environment Canada, Indian and Northern Affairs Canada, and the Saskatchewan Health Board. The findings were published in SRC Technical Report No. 217 (June 1988).

The purpose of the study was to obtain data on baseline concentrations of uranium decay series radionuclides in the vegetation of N. Saskatchewan and adjacent N.W.T.

Three regions were sampled: Wollaston Lake, Cluff Lake and northernmost Saskatchewan/adjacent N.W.T. A total of 24 localities within these regions was sampled on the basis of a broad selection of plant species available in sufficient quantity. A total of 18 species representing the plant groups lichens, shrubs and trees was collected. Based on the environmental mobility, radiotoxicity and chemical toxicity, Ra-226, Pb-210 and uranium were selected for the purpose of this study.

The choice of tissues sampled was based on those most commonly used by animals in the food chain leading to man. For example, caribou graze only the upper portions of lichens and hence lower and dead portions of these plants were not sampled. Moose browse on twigs, therefore, leaves from birch, aspen, etc. were stripped from the stem after collection.

The data generated were assessed in terms of variability in levels among three study regions, among localities within these regions, and among plant species.

The results showed the difficulty in generalizing about radionuclide concentrations in vegetation at different locations because the species present vary from place to place. Notwithstanding, significant differences between the regions were detected. For example, Wollaston Lake region has slightly higher overall Pb-210 levels whereas northernmost Sask./N.W.T. has the highest overall Ra-226 levels. The Cluff Lake region has the highest overall uranium levels.

Considering the differences in localities within the region, Cluff Lake region is the most homogeneous, since there is no significant difference between localities within it; Wollaston Lake region is the most heterogeneous in this respect.

Among the plant groups, lichens have the highest Pb-210 and uranium levels, and shrubs have the highest Ra-226 levels. Multivariate statistical analyses revealed that the vascular plants were different from the non-

vascular plants in their pattern of element uptake. The presence of uranium in non-vascular plants is probably derived from wax particles (containing uranium) shed from the surface of conifer needles and locally transported in the atmosphere. Ra-226 did not show any affinity to either plant group.

There was no good correlation between the vegetation or soil concentrations of any of the three radionuclides and the stable elements that would be of predictive value. The potential effect of forest fires on radionuclide accumulation in vegetation was also investigated by sampling burned and unburned sites at five localities in the Cluff Lake region. No consistent effect could be detected in either of the two species studied or in the soil.

Project 602. Ecological behaviour of abandoned uranium tailings - phase III, was completed during 1988.

Environmental data from inactive or abandoned uranium mill tailings surfaces, and their associated waters and vegetation, represent a starting point for evaluating the significance of long-term radionuclide transport from the tailings to the vegetation and surface waters. This study describes some of the trends that are evident after the 10 to 20 years of abandonment of the tailings sites.

The concentrations of Ra-226 and Pb-210 appear to be higher in the Bancroft and Uranium City tailings than in those of Elliot Lake. Uranium tailings are generally higher than those in terrestrial areas. The levels of radium-226 and lead-210 do not differ significantly between the wet and dry areas of the tailings.

The concentrations of heavy metals (Co, Cu, Ni and Pb) in uranium tailings are at or below the mean concentration ranges reported for base metal tailings. Metal concentrations in surface waters are not of concern and the means are within recommended water quality guidelines for raw public water supplies.

The uptake of Ra-226 and Pb-210 by vegetation is a species-specific phenomenon and is not related to the tailings characteristics. From the results obtained when washed and un-washed leaves of white birch were compared, no evidence could be found to suggest that significant contamination of the above-ground biomass occurred as a result of aerial deposition.

HEALTH AND WELFARE CANADA (NHW)

703. Bioassay guideline for uranium.

704. Germanium detectors for in vivo measurements.

705. Studies on the solubility of uranium dusts in simulated lung fluid.

706. Uranium inter-comparison programs.

707. Natural radioactivity in drinking water.

708. Develop a methodology for the analysis of uranium in faeces.

709. In-vivo intercomparison services.

710. Acquisition and calibration of two new phoswich detectors.

HIGHLIGHTS. NHW PROJECTS - M. Limson Zamora. Gary H. Kramer

703. The bioassay guideline is in press. Both French and English versions will be available.

704. All germanium detectors for in-vivo measurements failed and must be replaced. New software is also required.

705. Work on the solubility of uranium dusts in simulated lung fluid has been suspended because of a shortage of staff.

706. The uranium intercomparison program is ongoing. Twice per year, samples are being circulated to approximately 14 laboratories. in March and August during 1989, instead of July and December for analysis either by fluorometry or radiochemical methods. Reports are circulated to participating laboratories, showing ranked performance.

707. A cooperative project is underway with the Province of Manitoba to study natural radioactivity in the water supplies of 130 communities using groundwater sources of drinking water.

The network sampling and analysis of uranium in drinking water consists of:

1) monthly sampling from Regina;
2) April, May and June sampling from Elliot Lake with quarterly composites for the balance of the year;
3) quarterly composites all year from Port Hope.

708. The Human Monitoring Laboratory, Bureau of Radiation and Medical Services, BRMD, has the Lawrence Livermore National Laboratory, LLNL, realistic and Rando phantoms that are used by in-vivo facilities to cross calibrate and check their monitoring equipment.

The LLNL has lung inserts that have activity (nat U and 93% enriched U) homogeneously distributed.

Each in-vivo facility in Canada has been visited this year.

710. Two new detectors have been ordered to replace the defunct detectors currently in the Human Monitoring Laboratory, but the project is on hold until the detectors are delivered. The detectors will be calibrated for nat-U and 93% enriched uranium, among other radionuclides.

INDIAN AFFAIRS AND NORTHERN DEVELOPMENT (DIAND)

801. Modelling the effects of uranium mine tailings on a permafrost environment.

802. Pattern of uranium, companion elements and radioisotopes in lichen heath associated with the uranium deposits near Baker Lake, N.W.T. prior to

mining operations.

803. Survey of radionuclides in vegetation, soils and sediments of Keewatin uranium mineralized areas.

804. General use document entitled "Radioactivity in the Northern Environment".

HIGHLIGHTS, DIAND PROJECTS - D.M. Barnett

801. A study to model the effects of uranium mine tailings on a permafrost environment (Environmental Studies #53) has been published. Also available is a User's Manual and program listing. The report was co-authored by M.K. Woo and J.J. Drake, Dept. of Geography, McMaster University.

As indicated by Environment Canada (P. Vasudev) DIAND was one of the sponsors of project 606, on radionuclide distribution on the vegetation of North Saskatchewan and adjacent Northwest Territories (SRC Report 217, June 1988).

MIDWEST JOINT VENTURE - W. Zeljeznak

Environmental impact studies were underway during 1988 as part of the mine approval program.

C. Chakravatti (DEN) reported at the Fall 1988 meeting that data were being gathered for mine development and that the shaft had been collared.

RIO ALGOM MINES LIMITED (RIO) - Biman Bihari

851. The development of wet barriers on pyritic uranium tailings (CANMET 508).

302. Lung cancer detection (CAIRS), Sputum cytology.

Collaborative studies of the underground environment are being conducted on a regular basis with CANMET.

SASKATCHEWAN ENVIRONMENT (SE) - C. Potter

860. Close-out studies for AMOK E pit have been on-going for two years. Field data were collected and a report is in preparation. Mr. Potter commented further that SMDC has a study group, (identifying research needs). Once priorities are established, funding may be provided.

On pathways of radionuclides, the route is lichen-caribou-man. SENES has done pathway analysis and prepared iso-concentration lines for a range up to 2 km from the mill.

Uranium mine waste rock can be a source of contamination, perhaps greater than liquid effluents from milling. The question arises, "Where should waste rock be placed?"

SASKATCHEWAN RESEARCH COUNCIL (SRC)

912. Compilation and statistical analysis of a data base on uranium-series radionuclides in aquatic biota in northern Saskatchewan (Sask. Health Research Board).

922. Analysis of caribou bones from the Northwest Territories for uranium-series radionuclides, cesium-137 and strontium-90.

923. Development of bioassays for toxicity testing.

924. Pre-development environmental monitoring at the Midwest Joint Venture test mine.

G. Smithson reported on progress at the June 1988 meeting.

912. Statistical analysis of a data base on uranium-series radionuclides in aquatic biota in Northern Saskatchewan (S. Swanson).

922. All analyses of caribou bones from the Northwest Territories are done. Report preparation would follow as time allowed (S. Swanson).

923. Bioassays are now available for toxicity testing using algae, invertebrates (Daphnia Ceriodaphnia) and rainbow trout for static renewal acute tests and chronic tests (chronic tests are available for Ceriodaphnia only) (S. Swanson).

924. Pre-development environmental monitoring protocols will be established (aquatic biology, hydrology, groundwater). The studies will be done in the McMahon Lake area and will include several locations in the watershed (Doug. Chambers, SENES).

UNITED STEELWORKERS OF AMERICA (USW)

302. Sputum cytology, Ontario uranium miners (CAIRS).

JOINT PANEL ON OCCUPATIONAL AND ENVIRONMENTAL RESEARCH
FOR URANIUM PRODUCTION IN CANADA

MATRIX OF RESEARCH AREAS

	OCCUPATIONAL	ENVIRONMENTAL
DEFINE CONDITIONS OF EXPOSURE	AECB 222, 232-3-4, 241, 256 AECL 109, 112, 113 CAIRS 302, 303 EMR 501 NHW 705 DEN,RIO,USWA 302	AECB AECL 101, 102, 103, 104, 105 DOE 605 -7-15 SRC 912, 922, 924
IDENTIFY ADVERSE EFFECTS	AECB 249 AECL 110, 112, 113 EMR 500, 501	AECB 246 AECL 110 DOE 608, 615 EMR 500, 501, 503, 508, 511 DIAND 801, 802, 803, 804 SE 860 SRC 923 CAIRS 304
RELATE EXPOSURE WITH EFFECT	AECB 209, 210 AECL 108, 110 -12-13	AECB 238 AECL 108, 110 DOE 615
ASSESS RISK	AECL 108 AECB 202, 219, 235, 243 254, 255, 258, 259	AECB 245, 247, 248 AECL 101, 102, 108 DEN 418
CONTROL HAZARD	AECB 252, 257 EMR 502 NHW 703, 704, 706, 708, 709, 710	AECB 244, 250, 251, 252 AECL 107 DOE 605 EMR 503, 509, 510 RIO 850 NHW 707

FORM 4/84

PROJECTS COMPLETED DURING 1988

See also the publications file for reports on active projects by each agency.

Project No.	Agency	Title	Output
		ATOMIC ENERGY CONTROL BOARD (AECB)	
202.		Ontario miners mortality study (Phase II).	Final report under review
208.		Ontario miners SIN evaluation study.	INFO-0264
220.		Ontario miners morbidity follow-up study.	
227.		Characterization of long-lived dust at a Saskatchewan mine-mill.	
228.		Movement of radionuclides between water and sediments.	Draft
229.		The waste management implications of concentrating slimes - II.	INFO-0195-2
238.		Transfer parameter: non-domesticated animals.	Draft final report under review
239.		Effect of soil on radionuclides in plants: a literature survey.	
240.		Transfer of radionuclides to human milk - phase 2 feasibility.	INFO-0192-2
241.		Technical evaluation of an instant working level meter.	Final report being publ.
242.		Catalog of data on uranium uptake, organ burden and excretion.	INFO-0260
244.		Remeasurement of Th-230 in the pore water of Lacnor tailings.	Draft final report under review
245.		Radiation sensitivity of organs other than man: a review .	" "
246.		Effect of soil on radionuclides in plants: a field study.	" "
249.		Erosion of surface and near-surface disposal facilities.	Final report being publ.
250.		Methodology for estimating probability of intrusion.	Final report being reviewed
251.		Optimization in the decommissioning of uranium tailings	Final report to be publ.
255.		Influence of trace gases on the mobility of radon daughters.	Draft report under review

257.	Review of thorium intake, organ burden and excretion rates.	Awaiting final report
258.	Epidemiological study of lung cancer among uranium miners of ERL at Beaverlodge.	Draft final report under review

ENVIRONMENT CANADA (DOE)

602.	Ecological behaviour of abandoned uranium tailings - Phase III.	Report publ. Feb. 1988
604.	Hydrogeologic research investigations RA7, East Bull Lake	Report to be publ.
605.	Interaction of radionuclides from abandoned uranium tailings with organic residues.	Draft report under review
606.	Radionuclide distributions in the vegetation of North Saskatchewan and adjacent N.W.T. (Sponsors DOE, DIAND, Sask. Health Research Board)	SRC Report 217 June 1988 Available from D. Lawson

PUBLICATION FILE

The first Annual Report of the Joint Panel for Occupational and Environmental Research for Uranium Production in Canada was produced in 1977.

This publication file contains references for only the current year, 1988, and the two preceding years, 1986 and 1987. The annual report for 1983 contains all previous lists of publications, as do earlier annual reports.

Publications should be obtained from the public literature or from the organization conducting or sponsoring the work.

The publication list includes specific project reports by member agencies, as well as other reports of relevance not necessarily associated with the projects listed in the Active Projects section.

ATOMIC ENERGY CONTROL BOARD (AECB) PUBLICATIONS: Listings for 1986

1. DSMA Atcon Ltd., "Comparison of radon and thoron daughter behaviour in two underground uranium mine environments", INFO-0164.

2. Beak Consultants Ltd., "Derivation of release limits for a typical uranium mining and milling facility", INFO-0165.

3. Duport, P.J. and Edwardson, E., Canadian Institute for Radiation Safety, "Determination of the contribution of respirable long-lived dust to the committed dose equivalent received by uranium mine and mill workers in the Elliot Lake area". INFO-0167-1,2.

4. SENES Consultants Ltd., "Electrostatic purification of uranium mine stope atmospheres", INFO-0173.

5. Walsh, M.L., W & W Radiological and Environmental Consultant Services Inc., "Doses resulting from intrusion into uranium tailings areas". INFO-0182.

6. McElroy, R.G.C. and Johnson, J.R., AECL, Chalk River Nuclear Laboratories, "Passive radon daughter dosimeters", INFO-0184.

7. Phillips, C.R. and Khan, A., University of Toronto, "Analysis of factors affecting aerosol, unattached fraction and radon progeny measurements in mines", INFO-0187.

8. Beak Consultants Ltd. and Golder Associates, "Waste management implications of concentrating slimes - characteristics and potential problems", INFO-0195-1.

9. Beak Consultants Ltd., "The cost of decommissioning uranium mill tailings", INFO-0198.

10. Robertson, R., Becquerel Laboratories Inc., "Feasibility study of the dissolution rates of uranium ore dust, uranium concentrates and uranium compounds in simulated lung fluid", INFO-0205.

ATOMIC ENERGY CONTROL BOARD (AECB): Listings for 1987

1. "Development of an automated method for determining the thorium content of soil samples and aerosols" INFO-2011.

2. "Laboratory system for alpha-particle spectroscopy", INFO-0233.

3. "Survey of data on the radionuclide content of fish in Canada". INFO-0231-1, and INFO-0231-2, Appendix.

4. "Regulatory criteria for the disposal of radioactive wastes", INFO-0217.

5. "Licensing of uranium mine and mill waste management systems", INFO-0218.

6. "Decommissioning of uranium mines and mills - Canadian regulatory approach and experience", INFO-0219.

7. "Review of effect of soil on radionuclide uptake by plants", INFO-0230.

8. "Transfer parameters in the water/forage/moose pathway", INFO-0244.

9. "The effect of changes in humidity on the size of submicron aerosols", INFO-0245.

10. "Transfer of radionuclides of the uranium and thorium decay chains in aquatic and terrestrial environments", INFO-0237 (E).

ATOMIC ENERGY CONTROL BOARD (AECB): lISTINGS FOR 1988

1. "Transfer of radionuclides to human milk - phase II feasibility". INFO 0192-2.

2. "Comparing personal alpha dosimetry with conventional area monitoring - time weighting methods of exposure estimation: a Canadian assessment". INFO 0257.

3. "Catalogue of data on uranium intake, organ burden and excretion", INFO 0260.

4. "Ontario miners SIN evaluation study". INFO 0264.

5. "The waste management implications of concentrating slimes-II", INFO 0195-2).

6. "Estimation of long-term probabilities for inadvertent intrusion into radioactive waste management areas: a review of methods". INFO-0275.

7. "Optimization of protection as a decision-making tool for radioactive waste disposal", INFO-0267.

ATOMIC ENERGY OF CANADA LTD. (AECL): Listings for 1986

1. Cornett, R.J., Chant, L. and Link, D., "Sedimentation of Pb-210 in Laurentian Shield Lakes": Water Pollution Research J. of Canada, vol. 19, pp 97-109, 1985.

2. Lee, D.R., "Method for locating sediment anomalies on lakebeds that can be caused by groundwater flow", J. of Hydrology, vol. 79, pp 187-193, 1985.

3. Champ, D.R., Moltyaner, G.L., Young, J.L. and Lapcevic, P., "A downhole column technique for field measurement of transport parameters", AECL-8905, 1985.

4. Moltyaner, G.L. and Killey, R.W.D., "Field studies of dispersion in porous media: analysis of experimental data", EOS vol 65, p 208, 1984.

5. Munch, J.H. and Killey, R.W.D., "Equipment and methodology for sampling and testing cohesionless sediments", Groundwater Monitoring Review, vol 5, pp 38-42.

6. Zach, R. and Barnard, J.W., "EWAM: a model for predicting food and water ingestion, and inhalation rates of man", AECL-8401, 1985.

ATOMIC ENERGY OF CANADA LTD (AECL): Listings for 1987

1. Johnson, J.R., Brown, R.M. and Myers, D.K., "An overview of research at CRNL on the environmental aspects, toxicity, metabolism and dosimetry of tritium", Radiat. Prot. Dosim. vol. 16, pp. 17-21, 1986.

2. Cooper, E.L., Brown, R.M. and Milton, G.M., "Determination of ^{222}Rn and ^{226}Rn in environmental waters by liquid scintillation counting", Proc. Conf. Low Level Techniques Group of the ICRM, Int. Committee for Radionuclide Metrology, Wurenlingen, Switzerland June 10-12, 1987. Environmental International.

3. Cornett, R.J., "Remobilization of trace contaminants from lake sediments", Proc. 4th Int. Symp. Interaction Between Sediments and Waters. Int. Assoc. Sediment Water Science, Melbourne, Australia, February 17-21, 1987.

4. Cornett, R.J. and Chant, J., "Speciation of arsenic and nickel in sediments of Moira Lake", a research report prepared for National Uranium Tailings Program, CANMET, EMR, Ottawa, Canada. DSS File No. 05GS. 23241-5-1716, CRNL-4029, 1987.

5. Dunford, D.W. and Johnson, J.R., "Genmod - a program for internal dosimetry calculations", AECL-9434, 1987,

6. Inch, K.J. and Killey, R.W.D., "Surface area and radionuclide sorption in contaminated aquifiers", Water Poll. Res. J. of Canada, vol. 22, pp. 85-98, 1987.

7. Johnson, J.R., Lamothe, E.S. and Kramer, G.H., "The measurement of low energy beta particle emitting radionuclides in the lung using phoswich detectors", Radiat. Prot. Dosim. vol. 20, No. 4, pp. 267-269, 1987.

8. Myers, D.K. and Gentner, N.E., "Some factors affecting the sensitivity of cultured human cells to high-let radiation", Radiat. Environ. Biophys. vol. 26, pp. 263-273, 1987.

9. Myers, D.K. and Werner, M.M., "A review of the health effects of energy development", Nuclear J. of Canada, vol. 1, pp. 14-24, AECL-9366, 1987.

10. Werner, M.M. and Myers, D.K., "Mortality among Long-term Chalk River employees", AECL-9344, 1987.

ATOMIC ENERGY OF CANADA LIMITED: Listings for 1988

1. Gentner, N.E. and Morrison, D.P., "Detection and impact on cancer causation of persons exhibiting abnormal sensitivity to carcinogens", in Research Needs in Toxicology, Proc. Workshop, Chalk River Nuclear Laboratories (Myers, K.K. and Osborne, R.V. Eds.), November 1987, AECL-9718.

2. Gentner, N.E., Morrison, D.P. and Myers, D.K., "Impact on radiogenic cancer risk of persons exhibiting abnormal sensitivity to ionizing radiation", Health Phys. vol. 55, No. 2, pp. 415-425, 1988

3. Killey, R.W.D. and Moltyaner, G.L., "The Twin Lake tracer tests: setting methodology, and hydraulic conductivity distribution", Water Resources Research, vol. 24, No. 10, pp. 1585-1612, 1988.

4. Killey, R.W.D. and Uchida, S., "The rooting depth of trees on the Canadian Shield in Ontario", Health Physics, Health Physics Society 1988.

5. Lee, D.R., "Six in situ methods for study of groundwater discharge", Proc. Symp. Interaction Between Groundwater and Surface Water. Dept. Water Resources Engineering, IAHR, the Int. Assoc. for Hydraulic Res., Lund, Sweden, 1987.

6. Moltyaner, G.L., Champ, D.R. and Young, J.L., "Modeling of contaminant transport in porous media: a case study", Proc. Conf. Ground Water Geochemistry Sciences, pp. 667-690, Assoc. of Ground Water Scientists and Engineers, Denver, Co., 1988.

7. Myers, D.K., Johnson, J.R. and Muller, J., "Radiation hazards in uranium mining: epidemiological and dosimetric approaches", Int. Workshop Radiological Protection in Mining, Darwin, vol. A, pp. 1-13, 1988.

8. Myers, D.K. and Muller, J., "Epidemiological follow-up of uranium miners in Canada", Radiation Protection Practice, 7th Int. Congr. of Int. Radiat. Prot. Assoc., vol. 1, pp. 167-170, 1988.

9. Vezina, A.F. and Cornett, R.J., "The transport of Fe and ^{59}Fe between water and sediments in Perch Lake, Ontario", Trace Metals in Lakes, Natural Water Res. Inst., Burlington, Ontario, 1988.

CANADIAN INSTITUTE FOR RADIATION SAFETY (CAIRS): Listings for 1986

1. Action on radiation. The CAIRS action plan to assist Canadians exposed to radiation in the workplace, 1987-1990.

2. CAIRS radiation safety bulletin, vol. 4, No. 1 and 2.

3. Bancroft uranium tailings. Information obtained by CAIRS from the Federal and Ontario governments.

4. Reports on uranium mine radiation safety course, 1/86 and 2/86.

5. Radiation safety for Canadians. An invited brief to the New Democratic Party's inquiry into nuclear energy. CAIRS, Toronto, 6 p, 1986.

CANADIAN INSTITUTE FOR RADIATION SAFETY (CAIRS): Listings for 1987

1. "All about radiation". A radiation safety training program for Canada's uranium mine and mill workers. Training manual for Module 1.

2. CAIRS Radiation Safety Bulletin. vol. 5, No. 1 and 2.

3. "Radioactive and toxic wastes from the Bancroft uranium mines. Where are we going? Who is in charge?" CAIRS Report Stage II.

4. "Report: the uranium mine radiation safety course". 1/87 and 2/87.

5. The CAIRS List 1987-1988, La Liste CAIRS. Radiation Safety Training in Canada. Cours de radioprotection au Canada.

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1. Swanson, S.M., 1987. "Radioactivity from uranium mining and its relationship to fish"; SRC Report No. E-901-7-G-87.

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JOINT PANEL PUBLICATIONS

From the working group on Internal Dosimetry:

JP-1. "Research needs related to internal dosimetry", by P. Duport (AECB), C. Pomroy (AECB) and D. Brown (Sask. HURLE).

From the working group on Personal Dosimetry:

JP-2. "Some practical and theoretical considerations of personal alpha particle dosimetry", by J. Bigu (EMR) and P. Duport (AECB).

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JOINT PANEL ON OCCUPATIONAL AND ENVIRONMENTAL RESEARCH
FOR URANIUM PRODUCTION IN CANADA

APPENDIX

DATE	STATEMENT OF PROJECT	PROJECT #

TITLE	MATRIX LOCATION

OBJECTIVE

SCOPE OF WORK	
	ANTICIPATED COST

RESEARCHER(S)	ANTICIPATED COMPLETION DATE

SPONSOR(S)	CONTACT

FORM 1/84

JOINT PANEL ON OCCUPATIONAL AND ENVIRONMENTAL RESEARCH
FOR URANIUM PRODUCTION IN CANADA

DATE	REPORT ON PROJECT PROGRESS	PROJECT #

TITLE	MATRIX LOCATION

PROGRESS/STATUS

CHANGES	ANTICIPATED COST ANTICIPATED COMPLETION DATED

SPONSOR(S)	CONTACT

FORM 2/84

JOINT PANEL ON OCCUPATIONAL AND ENVIRONMENTAL RESEARCH
FOR URANIUM PRODUCTION IN CANADA

DATE	PROJECT COMPLETION REPORT	PROJECT #

TITLE	MATRIX LOCATION

DISPOSITION/STATUS

(Please quote abstract of publication if appropriate)

PUBLICATION AVAILABILITY	FINAL COST

SPONSOR(S)	CONTACT

FORM 3/84